|  |
| --- |
| **Lesson Title: Motion, Velocity and Acceleration Lab** |
| **Subject area / course / grade level: 5th grade Science and Language** |
| **Introduction**:  Imagine that you're in a car traveling at a high speed and accelerating quickly. You're heading directly toward a tree, and you continue to accelerate until you reach that tree. It sounds like you're in BIG trouble, doesn't it? Not necessarily. When we hear the word acceleration, we usually assume it means "increasing in speed." In many cases, that's exactly right. But sometimes in the Scientific world, acceleration is defined as "a rate of change of velocity." This change can be either an increase or a decrease in speed, or a change in direction.  The definitions of speed and velocity also may also differ from ones you already know! Each of these words may have its own distinct meaning. Speed can be defined as the rate of motion and is calculated by dividing the distance an object travels by the time it takes to travel that distance. Velocity, on the other hand, is a vector quantity -- a measurement of both the rate of motion (i.e., speed) plus direction. In other words, ten kilometers per hour is speed; east at 10 kilometers per hour is velocity. So, what do you think the word vector means? Vectors are quantities that have a size and direction.  Speed, velocity, and acceleration can be shown by using graphs. A graph illustrating time vs. speed, for example, provides a record of how the speed of an object changes over time. From such a graph, it's also possible to see whether an object is traveling at a constant rate or accelerating: A line parallel to the time axis isn't changing its speed, while one that's slanted is. |
| **Lesson Length: 4 hours** |
| **Materials**:  Science notebooks, Constant Velocity Toy Car, Stop Watches, Meter sticks, Computers with graphing software such as ChartTool (<http://www.onlinecharttool.com>).  Interactive website: http://www.teachersdomain.org |
| **Lesson Overview:**  Students will collect data of the motion of a toy car. The data will be graphed on a computer.  The interactive website shows how vectors are used to represent velocity (speed and direction) and acceleration. In the activity, vectors change in real time as you "drive" a car on a flat plain; as you change speed and direction, vectors originating from the car respond to your actions. A graph depicting speed vs. time also responds to your actions, displaying both the speed and acceleration of the car. |
| **Tennessee Standards:**  **Language Arts:**  1. Demonstrate confidence and poise in various speaking situations  2. Demonstrate critical listening skills essential for comprehension and evaluation  3. Engage in problem solving through group discussions  4. Present and support ideas/opinions in group discussions  5. Demonstrate appropriate language structure, tone and voice control in oral communication  **Science:**  GLE 0507. Inq. 2. Select and use appropriate tools and simple equipment to conduct an investigation.  GLE 0507. Inq.3. Organize data into appropriate tables, graphs, drawings, or diagrams.  0507. Inq. 2. Identify tools needed to investigate specific questions.  0507. Inq. 3. Maintain a science notebook that includes observations, data, diagrams, and explanations.  0507. Inq. 4. Analyze and communicate findings from multiple investigations of similar phenomena to  reach a conclusion.  GLE.0507.11.1 Design an investigation, collect data and draw conclusions about the relationship among  mass, force, and distance traveled.  **Math: NCTM**  Trace the source on any large disparity between estimated and calculated answers to problems.  Consider possible effects of measurement errors on calculations.  Recognize the relationship between accuracy and precision.  Express appropriate numbers of significant figures for calculated data, using scientific notation where appropriate.  Solve scientific problems by substituting quantitative values, using dimensional analysis, and or simple algebraic formulas as appropriate. |
| **Lesson objective(s):**  **●** Investigate the motion of two toy cars to determine why their motion is different.  ●Understand the difference between speed and velocity.  ●Distinguish between average speed and average velocity.  ●Define acceleration.  ●Interpret graphs of position versus time to determine the velocity of an object.  ●Recognize the meaning of the acceleration due to gravity  ●Define vector  ●Create motion graph with technology |
| **ENGAGEMENT**  Using their lab notebooks, students will be asked to observe the motion of two toy cars (one fast and one slow) and to describe their motion. They are then asked to predict what a graph of distance versus time would look like. After time is given for students to record their personal thoughts, they are then divided into groups of three or four and asked to show their descriptions of motions and graphs on their white boards. When all boards are complete and displayed to the class, allow each group to explain their board to the class. (Try not to make any statements as to whether the information presented is correct or incorrect.) Make sure the following questions have been addressed after the discussion:  1) How does the motion of the two cars differ?  2) Is the speed of the cars changing or staying the same?  3) How can we determine if the speed is staying constant?  4) What equipment would we need to do this investigation?  5) How would we record our data? |
| **EXPLORATION: Visual Imagery, Venn Diagram, and Knowledge Rating.**  ●Provide instruction on how to keep a laboratory notebook showing materials, equipment and data table.  ●Explain to students that we want time to be the independent variable (plotted on the horizontal axis) and distance to be  the dependent variable (plotted on the vertical axis).  ●Divide students into groups of three or four. Provide students with meter sticks, stopwatches, post-it notes, and battery  operated toy cars and explain to them good techniques needed to collect data.  ●Students should place a post-it note on the floor to mark the zero position, turn the car on and place it on the floor so  that the back of the car is lined up with the post-it note. Release the car and start the stop watch at the same time.  After 4 seconds, the students need to place a post-it note on the floor behind the car to make the car’s position.  Repeat this at the 8 second mark, 12 seconds and so on until all of the seven post-its have been used up. Stop the  car and use a meter stick to measure the distance from the zero position to each post-it note. Record the distances in  the data table.  ●Have each group present their data table on their whiteboards to show to the class.  TSW will display their knowledge of motion, acceleration, and velocity on their group’s graffiti board. The students will not be allowed to use their books as a guide. The graffiti boards will prompt students to: select the best means to share their ideas and thoughts, build upon other students’ ideas or thoughts, use think time before recording their ideas, be creative in their responses, and record their prior knowledge before reading/writing a text. |
| **EXPLANATION**  **Think-Pair Share, Text Connections**  It's possible for an object to be moving at a constant speed and be accelerating at the same time. Take as an example a car driving in a circle at 30 kilometers per hour. Although its speed is constant, its velocity is continually changing because its direction is continually changing as well. This change of direction results in an acceleration toward the center of the circle. Likewise, a satellite in circular orbit around Earth is traveling at a constant speed and accelerating toward Earth's center.   Engineers who design cars are keenly aware of acceleration resulting from a change in direction. With safety in mind, they use tires that provide enough friction to keep their cars from losing control when rounding corners. To increase the friction force for a fast-moving car, some engineers design the car's body shape to "hug" the ground. When moving fast enough, the car's body deflects air upward, forcing the car downward. This downward push increases the friction force between the tires and the ground. |
| **ELABORATION**  **Discussion Web**  **Discussion questions**  After all groups have finished collecting their data, ask the students if they are able to determine from the data table if the toy cars were moving at a constant speed. Ask them if they think a graph would help them decide if the cars were moving at a constant speed.  Have each group go to the free online graphing program ( <http://www.onlinecharttool.com>) and graph their data. Provide each student with a handout containing specific instructions on how to use the software. After each group has graphed their data, have them sketch their graph on their whiteboard. After each group has finished their white board, have them present them to the class. Ask the following questions:  1) What do all of the graphs have in common?  2) What do they think the straight line means?  3) Are there any differences in the graphs?  4) What is the formula for speed?  5) What part of this graph represents speed?  6) What does a graph with constant speed look like?  7) How would a graph with speed that is changing appear?  8) How do the graphs from the slow cars differ from the graphs of the fast cars?  9) What is causing the difference in distance?  Open the battery compartments of a fast and a slow car and allow the students to see what has been done to each car.  10) Ask the students about how the force applied by the battery is different between the cars. If each battery is able to apply a certain amount of force to the gear system of the car, then what happens to the force when one battery is removed?  11) What happens to the distance when the force is decreased?  After the discussion, allow each group time to print their graph and glue it in their lab book. (If printing the graph is not possible, then have each student sketch the graph in their lab notebook.  12. What is the difference between speed and velocity?  13. Define acceleration. What does it mean besides an increase in speed?  14. What if the graph showed acceleration rather than speed? Where would the line be when the car was continuing at  a constant speed of 40 mph in the same direction? Where would the line be if the speed were continually increasing?  Decreasing?  15. An object, such as a planet, circling another object, such as the Sun, at a constant speed is said to be accelerating.  Explain why this motion is an example of acceleration. |
| **EVALUATION: Graffiti Boards**  Students need to write a conclusion to their lab activity. Questions that need to be answered in their lab books:  1) Describe the motion of the toy car. How do you know?  2) What does a graph of an object with constant speed look like?  3) How does a graph of a fast object differ from the graph of a slow object?  4) How does the force applied to the car (from the battery) affect the distance the car travels?  5) Using the formula speed = distance/time, calculate the speed of your toy car.  TSW will display their knowledge of motion on their group’s graffiti board. The students will not be allowed to use their books as a guide. The graffiti boards will prompt students to: select the best means to share their ideas and thoughts, build upon other students’ ideas or thoughts, use think time before recording their ideas, be creative in their responses, and record their prior knowledge before reading/writing a text.  **Vocabulary**   |  |  |  | | --- | --- | --- | | motion | vector | force | | reference point | weight | friction | | speed | mass | energy | | velocity | Newton | potential energy | | resultant velocity | inertia | kinetic energy | | acceleration | gravity | axis (x,y) | |